IMPROVING YIELD
AND QUALITY OF FORAGE
MAIZE

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SUMMARY

Maize silage is recognised world-wide as a high quality winter feed for livestock. Attempts to introduce the crop to Ireland in the early 1970's failed because of the lack of suitable varieties. The release of maize varieties adapted to the colder North European and Irish climates has for the first time offered Irish beef and dairy farmers the opportunity to exploit the valuable assets of this crop.

The transfer of the technology of growing maize under photodegradable polythene developed in France could further enhance the development of forage maize production in Ireland.

The results presented show that the early type hybids released over the past five years are capable of producing high yields of high quality silage in selected sites across Ireland. To achieve satisfactory yields, site selection, early sowing and the use of adapted early maturing varieties is essential.

Sowing maize through a photodegradable polythene film laid on the soil surface has proved successful. This technique can increase yields on average by 3.5 t/ha, increase dry matter content by 5% and starch content by ten percentage points. The system also advances maturity by approximately three weeks, guaranteeing that on most farms the maize crop will be mature and ready for harvest before the first heavy autumn frost.

INTRODUCTION

Maize is one of the three major crop plants in world agriculture, surpassed only by rice and wheat. Within Europe 50% of the crop is grown for grain, the remainder, in the more temperate climatic areas, is grown for forage. Maize is attractive as a preserved forage because of its inherent quality, capable of increasing the forage intake of cattle and sheep and producing higher liveweight gains and higher yields of high protein milk than other conserved forages.

The first evaluation of maize took place in Ireland between 1971 and 1975 with little success. Yields and particularly the quality of the silage produced was considered inferior to grass. The general consensus at the time was that until varieties more adapted to our lower temperatures became available, maize was not a viable crop in Ireland (Neenan, 1976).

In the intervening twenty years breeders have produced a range of early maturing varieties adapted to the lower temperatures prevailing in Northern Europe. Examination of trial results published by the National Institute of Agricultural Botany in the U.K. show that the considerable progress made warranted a re-examination of forage maize in Ireland.

The use of polythene is now well established as a means of improving growth and development in crop plants. The increased accumulated temperatures (degree days) available result in higher yields and earlier harvest. Work in France with polythene film applied to the soil surface as a mulching agent to conserve soil moisture showed that soil temperatures were increased by up to 5^{o}C. This could be of considerable benefit for maize growing in Ireland.

The objective of the present study was to examine the effects of new early maturing varieties , sowing date and polythene soil cover on the growth, yield and quality of forage maize.

METHODS

Fully randomised field trials were carried out at Oak Park and other sites. The plots were sown with a four-row commercial drill. Plot size was standardised at 4 rows, 70 cms apart and 20 m long (56 m^2). Ten metre lengths of the two centre rows (14 m^2) were harvested by hand, approximately 12.5 cms above ground level, for yield assessment. A sub-sample of plants was chopped and dried at 100^{o}C for 24 hours to determine dry matter content. At harvest ten consecutive plants in one of the two centre rows were taken for further analysis. The cobs were removed and stripped of leaf sheaths and stem. Both fraction, cob and all other material were dried separately. The data derived allowed the determination of cob dm %, % cob dry matter, cob yield and grain yield.

RESULTS AND DISCUSSION

Variety

Situated as Ireland is on the margins of the European maize growing area, variety choice is critical in achieving good yields of high quality silage. Examination of the N.I.A.B. Recommended List publications over the last twenty three years shows clearly the advances achieved in both yield and the level of maturity in early type varieties (Table 1).

Table 1: Comparisons of the best early maize hybrids 1973-1996

Variety	Yield d.m. t/ha	D.M. %	Years tested	Year placed on Recommended List
Dekalb	10.85	25.0	1970-1973	1973
L.G. 11	11.54	28.7	1978-1980	1976
L.G. 20.80	11.29	31.0	1984-1988	1987
Botanis	12.08	36.4	1986-1990	1991
*Melody	13.86	38.6	1990-1994	1993
*Lincoln	14.67	35.1	1993-1996	1996

Source: NIAB Recommended List of maize varieties 1973-1997

*Varieties now sown commercially in Ireland

Comparing the best early variety in 1973 with the best in 1996 shows an average yield increase of 1.5% per year and an increase of over 10% in the level of dry matter content attained. A series of variety trials over the years 1990-1997 with twelve early hybrids (Table 2) demonstrates the potential of these new varieties for forage production in Ireland.

Table 2: Performance of forage maize over seven years (1990-1997)

Character	1991	1992	1993	1994	1995	1996	1997
DM yield (t/ha)	14.7	13.4	8.8	10.6	16.2	14.6	15.4
DM %	26.6	26.6	21.1	24.1	34.7	25.9	35.1
Cob yield (t/ha)	6.9	5.0	1.5	2.5	9.4	7.7	8.9

Only in 1993, which was an exceptionally unfavourable summer, did maize fail to produce an acceptable yield, while in 1995 and 1997 yield, maturity and cob yield (starch content) were equivalent to the best continental maize. As a result the area sown to forage maize has increased from less than 50 hectares in 1990 to around 7,000 hectares in 1997.

The level of accumulated temperature (degree days) is very important in the relative performance of maize varieties. So location and site choice within any location can have a very significant effect not only on the total dry matter production but on the grain and hence starch levels attained. Data from 1997 variety trials at five sites illustrate this effect (Table 3).

Table 3: The effect of location on the yield and quality of forage maize - 1997 (averages over 12 varieties).

Location	DM yield t/ha	DM %	Grain dm yield t/ha
Carrick-on-Suir Co. Tipperary	17.9	27.7	6.9
Newcastle Co. Wicklow	16.3	29.0	5.6
Bandon Co. Cork	15.7	25.4	6.5
Lyons Estate Co. Dublin	12.0	26.4	4.3
Dromore Co. Down	12.1	20.8	1.3

Dromore, Co. Down, the most northerly location, while producing a reasonable yield of dry matter, the quality as measured by grain yield, was extremely low compared to the more southerly sites. An examination of the performance of individual varieties highlights the high level of variety x location interaction, an important feature of maize varieties. The data in Table 4 illustrate the point.

Table 4: The relative performance of five maize varieties at two locations - 1996

	Carrick-on-Suir		Dromore	
Variety	Total dm yield	Grain dm yield	Total dm yield	Grain dm yield
Nancis	96	105	101	159
Loft	100	108	113	138
Hudson	106	125	109	106
Rival	102	115	104	58
Janna	111	110	99	50
Trial mean t/ha	17.9	7.6	11.7	1.65

Nancis and Loft, while producing an average relative performance in the high yielding site at Carrick-on-Suir, produced the highest grain yields at Dromore, while Janna performed poorly in the most northerly site.

Date of sowing

The maize plant is vulnerable to frost damage in both spring and autumn. Although maize requires a soil temperature of 10^{o}C to germinate, generally not reached until the last week of April, sowing once the soil temperatures reach 8^{o}C produces the highest yield of dry matter. While maize seedlings are vulnerable to frost damage, the experience to-date indicates that May frosts will not kill the seedlings as the growing point is still below the soil surface. Slight leaf damage and a check on growth can occur but the crop quickly recovers. Sowing in mid to late April also ensures that the crop will have reached an acceptable level of maturity before the first serious autumn frost, which can occur any time from late September.

To a large extent the last spring air frost and the first autumn air frost (below -2^{o}C) determine the length of the growing season and therefore the degree of maturity and the quality of the crop produced. To establish the optimum date of sowing for maize a "variety by time of sowing" trial was carried out in 1992 and 1993. A summary of the data is presented in Tables 5 and 6.

Table 5: The effect of sowing date (average over three varieties) on a range of production characters in maize - 1992

Date of sowing	DM yield (relative)	DM %	Cob DM %	Cob % DM	Cob DM yield (relative)
10 April	94	24.7	26.2	28.2	126
20 April	107	24.9	24.8	25.9	130
10 May	100	23.8	20.9	19.1	91
20 May	98	22.4	15.4	12.2	56

Table 6: The effect of sowing date (average over three varieties) on a range of production characters in maize - 1993

Date of sowing	DM yield (relative)	DM %	Cob DM %	Cob % DM	Cob DM yield (relative)
19 April	115	22.6	22.1	35.3	214
28 April	105	19.2	15.8	24.0	133
13 May	87	17.8	8.3	8.9	41
04 June	92	18.5	5.5	2.5	12

In both years the early sowing (19/20 April) produced both the highest total dry matter yield, dry matter content and cob dry matter yield. The earliest sowing 10 April, 1992, (Table 5) although producing the most mature crop, produced significantly less total dry matter yield.

Polythene use in maize growing

Despite the improvements achieved, maize can give low dry matter yield in cool, dull seasons. Improving production reliability was seen as an important research priority at Oak Park. To this end, the French system of maize production under plastic was evaluated from 1994-1997. Growing maize, using a photodegradable polythene film as a soil mulch, was developed and perfected in France during the 1980's. The technique was developed as a method of soil moisture conservation and proved very successful in increasing both the yield and quality of the forage maize. The increased soil temperatures recorded (up to 5^{o}C) under the plastic film were not considered important in France but could be of major importance in Ireland.

The technique, generally referred to as Punch Plastic, involves laying two sheets of a 1.5 metre wide photodegradable polythene thin film (12 microns thick) on the soil surface and sowing two rows of maize, 70 cms apart, through each sheet. The seeding mechanism punctures the film at each individual seed position. This allows the seedlings to emerge through the punctured hole and develop free of the plastic. This whole operation is carried out with a specially designed one-pass machine. The polythene breaks down during the season and more or less disappears by harvest time (Crowley, 1996.)

The benefits of sowing under plastic come primarily from increased soil temperatures. A very significant increase in soil temperature was recorded within one day of sowing. A summary of the data recorded, averaged over 30 day blocks is presented in Table 7.

Table 7: The effect of photodegradable film on soil temperature (^{o}C) in 1994 and 1995 compared to the 30-year average.

Month	Year	+ Plastic	- Plastic	Difference	30-year average
	1994	12.7	9.7	3.0	
May	1995	14.9	11.4	3.5	13.1
	1994	16.6	13.7	2.9	
June	1995	19.9	16.0	3.9	17.0
	1994	17.3	15.9	1.4	
July	1995	20.0	18.4	1.6	18.2

The results show that (a) normal soil temperatures were significantly higher in 1995, but still below the 30-year average and (b) the response under plastic was in the order 3.0^{o}C+ in both May and June, decreasing to 1.5^{o}C in July as the polythene cover degraded and the crop canopy developed, shielding the polythene from direct sunlight. The soil temperature changes recorded across the polythene strip showed a significant fall from the centre to the alleyway between the polythene strips (Table 8).

Table 8: Average monthly soil temperature ^{o}C at 10 cm for May and June across the polythene strip - 1995

	Polythene strip			No polythene
Month	Centre	Edge	*Gap	
May	14.9	13.0	12.1	11.4
June	19.9	17.7	17.2	16.0

*Gap = wheel width between the two strips sown in one pass

The increased soil temperatures resulted in quicker germination and establishment but had no effect on the number of plants established. Overall the number of plants established in 1995 was significantly higher at 94,000/ha (38,000/ac) than achieved in 1994, 79,000/ha (32,000/ac).

The early growth and development under plastic resulted in more advanced crops compared to the "no plastic" controls in 1994 (Table 9).

Table 9: The effect of polythene on the date of flowering (tasseling) at two sites 1994

Location	Variety	+ Plastic	- Plastic	Days advanced
Fermoy	Janna	26 July	15 August	20
Oak Park	LG. 20.80	02 August	23 August	21
	Apache	08 August	26 August	18
	Calypso	14 August	03 Sept	20

With 1995 breaking all records for temperature and sunshine levels, the advancement of in-flowering under plastic was reduced to 10 days.

Total dry matter yield, crop DM % and grain dry matter yield and consequently starch content (%) were all increased at all sites by the use of polythene (Tables 10 and 11).

Table 10: Dry matter yield, DM% and % cob DM of maize grown with and without plastic in 1994

Site No.	DM Yield t/ac			Crop DM %		Cob DM %	
	+ Plastic	- Plastic	Difference	+ Plastic	- Plastic	+ Plastic	- Plastic
1	15.5	11.0	4.5	21.9	19.6	35.1	18.2
2	12.0	9.2	2.8	17.7	16.7	17.3	11.0
3	14.0	9.0	2.03	21.9	18.2	41.0	17.1
4	14.3	8.5	5.0	22.1	16.6	38.0	14.5
5	16.0	12.5	5.8	25.5	21.9	51.8	32.0
6	11.7	8.1	3.5	19.0	17.3	26.1	8.5
7	12.9	9.0	3.9	18.9	17.0	12.9	3.4
Mean	13.8	9.6	4.2	21.0	18.2	31.7	15.0

Table 11: Dry matter yield (t/ha) crop DM%, grain yield (t/ha) and starch % of maize grown with and without plastic 1995

	Total dm yield (t/ha)		Crop dm (%)		Grain dm yield (t/ha)		Starch content (%)	
Site	+	-	+	-	+	-	+	-
1	17.6	16.1	28.6	26.2	7.5	5.9	30.9	19.6
2	18.3	15.0	29.1	26.7	7.6	4.8	29.7	21.1
3	18.4	16.0	35.1	27.1	8.2	4.3	33.4	19.1
4	15.7	13.0	29.6	25.2	6.3	3.6	29.7	18.7
5	17.1	13.1	29.5	25.4	6.1	3.7	25.9	19.1
6	17.5	14.8	34.2	28.7	7.4	4.3	31.6	20.5
7	17.6	14.6	30.5	25.7	7.7	4.6	33.1	23.5
Mean	17.5	14.7	30.9	26.4	7.3	4.5	30.6	20.2

Averaged over the seven sites and the two years DM yield increased by 3.5 t/ha, DM% by 5.3 and grain yield by 2.5 t/ha indicating that 71% of the increased dry matter yield achieved was in the form of grain. The exceptional weather during July and August 1995 resulted in a high yield of well formed mature cobs. The composition of the cobs and starch content of the grain, compared to those produced in 1994 are shown in Table 12. Here the benefits from the polythene are substantial even when weather conditions were ideal for maize production.

Table12: The effect of polythene film on the composition of maize cobs in 1994 and 1995

	1995		1994	
Character	+ Plastic	- Plastic	+ Plastic	- Plastic
% grain	80	72	63	38
% spindle	20	28	37	62
Grain starch content %	73.8	69.6	54.6	37.0

Even in an exceptionally good year for maize production the use of polythene film increased dry matter yield by an average 2.8 t/ha; starch content by 10%, (from 20.1% to 30.3%) and brought forward the harvest date by approximately three weeks. To achieve an economic benefit from the use of polythene film, all the requirements for growing a good crop of maize must be met. These include selection of a suitable site and careful attention to both soil management, seedbed preparation and weed control. The optimum sowing time is mid-April to early

May. Crops sown before mid-April run the risk of serious frost damage. Sowing later in May will result in low DM and low starch silage.

CONCLUSIONS

- The release of new early maturing maize hybrids makes maize silage a worthwhile option for dairy and beef farmers.
- Careful site selection is essential in achieving high yields of high quality material
- The optimum sowing date is as soon as soil conditions are favourable after mid-April.
- Early maturing varieties give best results.
- The use of photodegradable polythene gives quicker germination, faster growth and earlier flowering. It also increases both dry matter yield and starch content.
- Crops under polythene will reach harvest maturity up to three weeks earlier than conventional maize.

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